REMARKS

A. Status of the Claims / Amendments to the Specification, Claims and Drawings

In the Office Action/Final Rejection of February 18, 2009, the status of the claims was as follows:

Claims 1-63 were previously canceled.

Claim 68 was objected to as being in improper form.

Claims 64, 66-69, 71, 73 and 74 were rejected under 35 U.S.C. §102(b) based on Thompson '814.

Claim 65 was rejected under 35 U.S.C. §103(a) based on Thompson '814 and Hirai '962.

Claim 70 was rejected under 35 U.S.C. §103(a) based on Thompson '814 and Kido '209.

Claim 72 was rejected under 35 U.S.C. §103(a) based on Thompson '814.

The previous objections to the Drawings and the Specification have been withdrawn by the Examiner based on the last Amendment and Response.

In this Revised Amendment and Response, new Claims 75-90 have been added. Claim 64 has been amended to delete the word "essentially." Claim 68 has been amended to correct the obvious typographical error concerning claim dependency.

No new matter has been added. Support for new Claim 75 is found in Example 10 and Table 1 of the original disclosure at page 26, line 27 to page 27, line 24. Example 10 discusses the several ways in which an electroluminescent device fabricated with an electroluminescent layer in accordance with the device fabrication method (i.e., fabricated with zirconium quinolate) demonstrates surprisingly substantially improved performance

characteristics relative to an otherwise comparable device prepared in accordance with prior art techniques (i.e., fabricated with aluminum quinolate). As clearly shown in Table 1 (at page 27, lines 10-15), an electroluminescent device fabricated with a zirconium quinolate electroluminescent layer according to this invention demonstrates increased luminescence efficiency measurable as cd A^{-1}, increased luminescence measurable as cd m^{-2} at 20 mA cm^{-2}, and decreased turn-on voltage in comparison with a comparable aluminum quinolate-based device. New Claims 76-86 are dependent claims dependent, directly or indirectly, on new Claim 75. New Claims 77-86 generally correspond, respectively, to Claims 65-74 except for the claim dependency. New Claim 87 is a product-by-process claim dependent on Claim 64. New Claims 88-90, dependent directly or indirectly on Claim 87, correspond respectively to Claims 65, 66 and 72.

Support for the "consisting of" language in Claim 64 is derived from the Specification as a whole, which teaches a two-component layer of electroluminescent composition in which the first component is the host material (zirconium or hafnium quinolate) and the second component is the fluorescent dopant. No mention is made anywhere in the Specification of adding a further component to the electroluminescent composition. All of the application examples employ electroluminescent layers having only two components. A specific reference to two materials is found at page 4, lines 22-24 of the application.

B. Traverse / Request for Reconsideration of "Non-Responsive" Determination

Applicants respectfully traverse and request reconsideration in accordance with 37 C.F.R. 1.143 of the Examiner's determination in the Office Action of July 31, 2009 that the

new method Claims 65-86 submitted with a Request for Continued Examination (both filed May 20, 2009) "are not readable on the originally presented invention because the original claims were drawn to a device while the current claims are drawn to a method of making a device."

As clearly shown by the USPTO Filing Receipt, this application is a Sec. 371 of international application serial no. PCT/GB03/05573. Accordingly, this national phase application is controlled by PCT Unity of Invention rules under 37 C.F.R. 1.475. In this case, however, the Examiner did not reference 37 C.F.R. 1.475 "Unity of invention before the International Searching Authority ... and during the national stage," nor did he reference the related MPEP sections (Secs. 1850 and 1893.03(d)).

Specifically, 37 C.F.R. 1.475(b)(1) provides that "a national stage application containing claims to different categories of invention will be considered to have unity of invention if the claims are drawn only to one of the following combinations of categories: (1) A product and a process specially adapted for the manufacture of the said product...." Applicants respectfully submit that the previously pending claims were related to the new claims presented in the Amendment and Response filed May 20, 2009 in a relationship of product (an electroluminescent device) and a process specially adapted for the manufacture of the said product, thereby coming within the scope of 37 C.F.R. 1.475(b)(1). Accordingly, Applicants submit that the Examiner's determination that the new claims were "not readable on the originally presented invention" is inconsistent with 37 C.F.R. 1.475(b).

This Revised Amendment and Response presents the previously-pending set of product claims (Claims 64-74), a new set of method claims (Claims 75-86) directed to a "process specially adapted for the manufacture of the [product of Claims 64-74]," and several

new product-by-process claims (Claims 87-90). In accordance with the foregoing discussion, Applicants respectfully submit that all of these Claims 64-90 come within PCT Unity of Invention consistent with 37 C.F.R. 1.475(b).

C. Sec. 102(b) Rejection – Thompson '814

1. Claims 64, 66-69, 71, 73 and 74

Claims 64, 66-69, 71, 73 and 74 were rejected under 35 U.S.C. §102(b) as being anticipated by the Thompson '814 patent (para. 7 of the Office Action of February 18, 2009). Claim 64 has now been amended to recite that the electroluminescent composition "consists of" the metal quinolate and the dopant.

The well-recognized meaning of the transitional phrase "consisting of" is discussed in MPEP 2111.03. The phrase "consisting of" is properly interpreted as excluding "any element, step or ingredient not specified in the claim." Accordingly, Claim 64 as amended must be interpreted to exclude the presence of a "polarization dopant" as taught by Thompson '814.

The only reason given by Thompson '814 for even suggesting zirconium quinolate as an alternative to the aluminum quinolate host that is clearly preferred by the reference was to make the polarization dopant (in a 3-component "emissive layer" including "a host material, ... a dopant ... and a polarization molecule....") more effective by employing a host with zero dipole moment. Thus, on the basis of what is disclosed by Thompson '814, in systems that do not use a polarization dopant, there would be absolutely no reason to use, or even to try, anything other than aluminum quinolate, the material used in almost all of the Thompson '814 examples.

The classic technical paper on the use of doped aluminum quinolate is that of Tang et al, *J. Applied Physics*, Vol. 65, No. 9, 1 May 1989, 3910-3916 (a copy of which accompanies the Supplemental IDS filed herewith). The reasons for one to select aluminum quinolate as the host material for electroluminescent applications are disclosed in the Tang paper at page 3911, right hand column, namely that: (1) aluminum quinolate was considered to be one of the most stable and highly fluorescent compounds in the class of metal chelates; (2) aluminum quinolate was known to form smooth thin films; and (3) an evaporated film of aluminum quinolate was microcrystalline with a grain size <500Å. Accordingly, aluminum quinolate became the material of choice as the host material for electroluminescent layers, at least for generating red and green pixels. The extensive use of aluminum quinolate by OLED manufacturers is confirmed in a paper by Rajeswaran et al., *Journal of Chemical Crystallography*, Vol. 35, No. 1, January 2005 (a copy of which accompanies the Supplemental IDS). As stated in the Rajeswaran et al. publication:

> "The interest in organic materials for use in organic light-emitting diodes (OLEDs) began with the pioneering report of efficient green electroluminescence from Alq_3, tris(8-hydroxyquinoline) aluminum by Tang and Van Slyke. After more than 17 years of intense research and development in OLEDs, Alq_3 continues to be the most widely used electroluminescent material in OLED chemistry. Alq_3 is used in electron transport and/or electron injecting layers in multiplayer device structures and also an as effective host material for various dyes."

The heart of the technical problem to which this invention is directed is to find a material that is <u>superior</u> to aluminum quinolate for use as an electroluminescent host material. The difficulty in solving this problem is demonstrated by the long period of time over which aluminum quinolate has remained the predominant material for such applications. In relation to a <u>two-component</u> electroluminescent layer, as now claimed in Claim 64, Thompson '814

gives no guidance or suggestion whatsoever as to what might be a generally better host material than aluminum quinolate.

The present inventors have made the surprising and unobvious finding that zirconium quinolate has a number of properties that, judged in combination, make it a material that may both be advantageously used in place of aluminum quinolate as host material in a two-component electroluminescent layer of an OLED, resulting in surprisingly improved performance, and also if desired used as an electron transport layer. When thus used, the electroluminescent device performance has been found to be markedly superior to comparable devices using aluminum quinolate, as clearly shown by the application examples. No teaching in Thompson '814 suggests these unexpected results. In particular:

(a) Zirconium quinolate has been found to serve as a like-for-like replacement for aluminum quinolate and thus can be substituted without requiring significant manufacturing process or equipment changes.

(b) Zirconium quinolate has been found to be useful with the same dopants as are used with aluminum quinolate. It has been found in this connection that the HOMO and LUMO levels for zirconium quinolate and aluminum quinolate are similar – the HOMO level for aluminum quinolate being –7.5eV and that for zirconium quinolate being –5.6eV, and the LUMO level of both compounds being –2.eV. Thompson '814 completely fails to recognize these important material characteristics of zirconium quinolate in these applications.

(c) Zirconium quinolate has been found to exhibit a higher electron mobility than aluminum quinolate, which in turn increases the current efficiency of the OLED. The reason for this increase is believed to be as follows: An electroluminescent device can be viewed as a diode which is forward-biased when the anode is at a higher potential than the cathode.

Under these conditions, the anode injects holes (positive charge carriers) into the luminescent layer, while the cathode injects electrons into the luminescent layer. The injected holes and electrons each migrate toward the oppositely charged electrode, which results in hole-electron recombination within the luminescent layer. When a migrating electron drops from its conduction potential to a valence band in filling a hole, energy is released as light. Maximum light output for a given current (i.e., maximum current efficiency) requires a balance between holes and electrons. Typically in OLEDs the majority carriers in are holes, thereby limiting the luminescent response. By providing for an increase of electron mobility in the electroluminescent layer, however, the surprising result is an improved balance between holes and electrons and hence an unexpected improvement in luminous efficiency. The performance improvements are indicated in Table 1 of the subject application and in Figs. 37-47. In this respect as well, Thompson '814 utterly fails to recognize these important material characteristics of zirconium quinolate in these applications.

(d) It has been found that there is a link between balanced majority and minority carriers and device lifetime. Specifically, the change from aluminum quinolate to zirconium quinolate as host material for the electroluminescent layer has surprisingly been found to improve device lifetime. (See, for example, the attached results for a green electroluminescent device using a proprietary dopant E036. It can be noted that the fall off of luminance over time occurs less quickly for a device having zirconium quinolate as <u>both</u> host and electron transport layer as compared to similar devices where the host is aluminum quinolate and the electron transport layer is either zirconium quinolate or aluminum quinolate. The observed improvement is a property of the host, not the dopant or of the other layers in the device which were the same for the three OLEDs tested.) Thompson '814

completely fails to recognize or even suggest that such a dramatic and unexpected improvement in luminescent life can be obtained with zirconium quinolate as the host material.

(e) Zirconium quinolate has no dipole moment which, as explained in earlier responses, gives rise to improved color characteristics. The improved CIE coordinates for doped aluminum quinolate reported in this application indicate a more saturated green. The emission of the doped zirconium quinolate device of this invention, by comparison, is much sharper and of higher intensity that for an aluminum quinolate-based device. Although Thompson '814 remarked on the zero dipole moment of zirconium quinolate, nowhere does Thompson '814 disclose or even suggest the advantage of the significantly better color that is realized in the two-component zirconium quinolate systems.

Use of zirconium quinolate as the electroluminescent host therefore provides a solution to the long-standing problem of finding a better replacement for aluminum quinolate in such systems. Furthermore, the attributes of zirconium quinolate which, in combination, make it especially suitable for use as a replacement for aluminum quinolate, were completely unrecognized prior to the present invention and would never have been arrived at by a person skilled in the art working from the state of the art, specifically the teachings of the Thompson '814 reference. It is therefore submitted that the claimed subject matter is patentable over the limited teachings of Thompson '814.

2. <u>Claims 75-90</u>

Because Claims 75-90 are new claims, they were not subject to any earlier rejections. Applicants respectfully submit, however, that these claims also clearly distinguish over the Thompson '814 reference.

As the Examiner correctly observed in para. 7 of the Office Action of February 18, 2009, "the reference [Thompson '814] is <u>silent</u> regarding 'wherein said device has the characteristics of a higher luminance efficiency measurable as cd A^{-1}, a greater luminance measurable as cd m^{-2} at 20 mA cm^{-2}, and a reduced turn-on voltage compared with a similar device in which said metal quinolate is aluminum quinolate'...." (emphasis added). Because Thompson '814 is "silent" concerning <u>any</u> of these performance characteristics, based on the teachings of Thompson '814 alone no one of ordinary skill in this art would have any basis for practicing the claimed device fabrication method.

D. <u>Sec. 103(a) Rejection – Thompson '814 / Hirai '962</u>

Claim 65 was rejected under 35 U.S.C. §103(a) as being unpatentable over the Thompson '814 patent in view of the Hirai '962 patent publication (para. 10 of the Office Action of February 18, 2009). Applicants respectfully request that this ground of rejection be reconsidered and withdrawn in view of the arguments in part C(1) above.

The Hirai '962 publication was cited solely to show that "perylene and acridine compounds [are] suitable light emitting compounds for an electroluminescent device." <u>Nothing</u> in Hirai '962, however, teaches or suggests the surprising performance characteristics that are the basis for the presently-pending claims. Accordingly, the citation

of Hirai '962 in combination with Thompson '814 still does not teach or suggest the claimed device, and the present claims should be deemed patentable over this reference combination.

E. Sec. 103(a) Rejection – Thompson '814 / Kido '209

Claim 70 was rejected under 35 U.S.C. §103(a) as being unpatentable over the Thompson '814 patent in view of the Kido '209 patent (para. 11 of the Office Action of February 18, 2009). Applicants respectfully request that this ground of rejection also be reconsidered and withdrawn in view of the arguments in part C(1) above.

The Kido '209 patent was cited solely to remedy the fact that Thompson '814 "does not explicitly disclose wherein the electron transport layer comprises lithium quinolate...." Nothing in Kido '209, however, teaches or suggests the surprising performance characteristics that are the basis for the presently-pending claims. Accordingly, the citation of Kido '209 in combination with Thompson '814 still does not teach or suggest the claimed device, and the present claims should also be deemed patentable over this reference combination.

F. Sec. 103(a) Rejection – Thompson '814

Claim 72 was rejected under 35 U.S.C. §103(a) as being unpatentable over the Thompson '814 patent (para. 12 of the Office Action of February 18, 2009). Applicants respectfully request that this ground of rejection also be reconsidered and withdrawn in view of the arguments in part C(1) above.

As discussed in part C(1) above, Thompson '814 is "silent" concerning the surprising performance characteristics that are the basis for the presently-pending claims. Accordingly, the present claims should be deemed patentable over Thompson '814 alone.

SUMMARY AND CONCLUSIONS

For all of the foregoing reasons, Claims 64-90 now pending should be considered in condition for allowance and an early notice thereof is earnestly requested.

Respectfully submitted,

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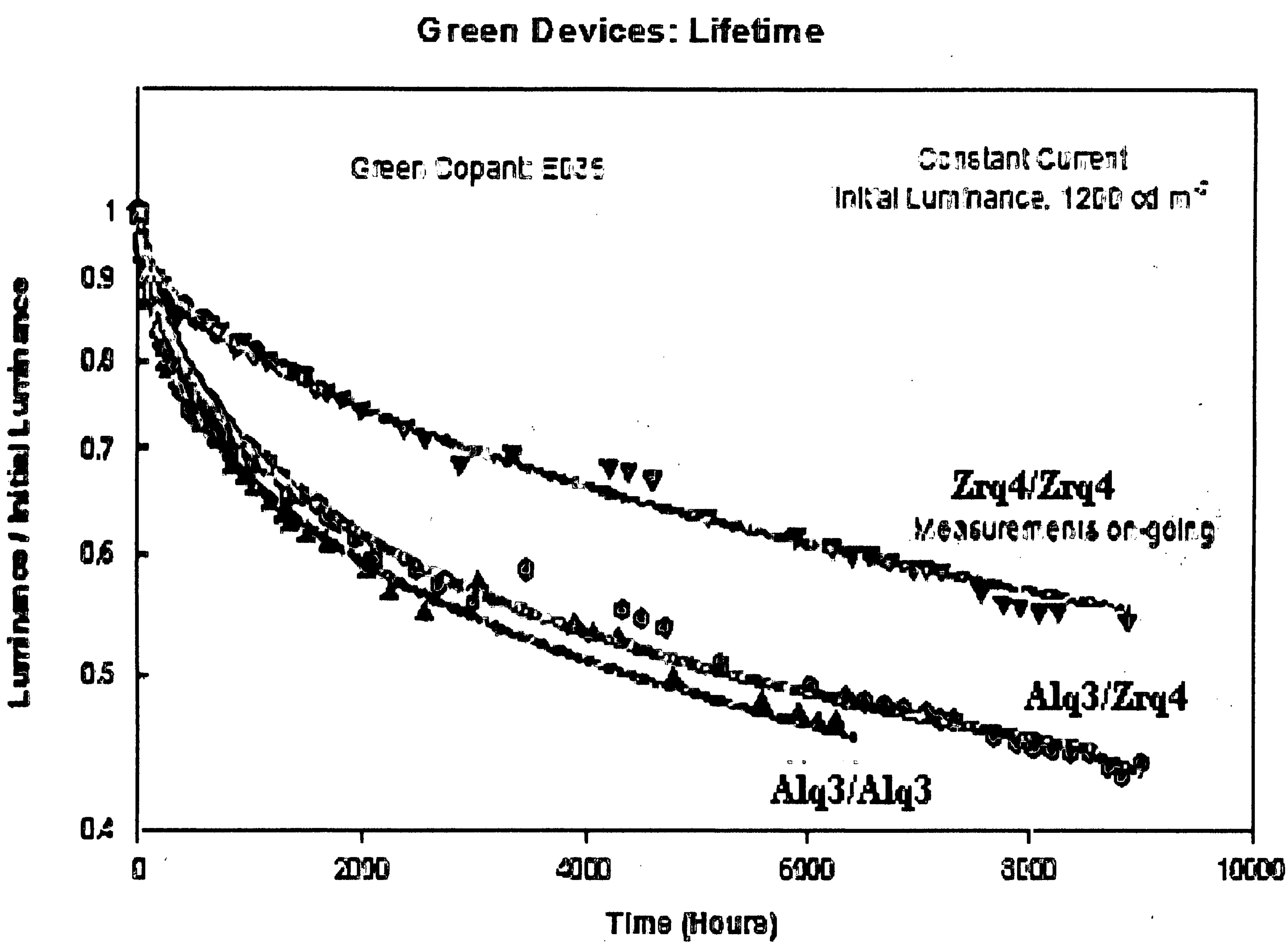

Green Devices: Lifetime
Green Dopant E035
Constant Current
Initial Luminance. 1200 cd m⁻²
Zrq4/Zrq4
Measurements on-going
Alq3/Zrq4
Alq3/Alq3
Luminance / Initial Luminance
Time (Hours)
0
2000
4000
6000
8000
10000
1
0.9
0.8
0.7
0.6
0.5
0.4